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Do social relations buffer the effect of neighborhood deprivation on health-related quality of life? Results from the LifeLines Cohort Study

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ABSTRACT

We investigated whether social relations buffer the effect of neighborhood deprivation on mental and physical health-related quality of life. Baseline data from the LifeLines Cohort Study (N=68,111) and a neighborhood deprivation index were used to perform mixed effect linear regression analyses. Results showed that fewer personal contacts (b, 95%CI: −0.88(−1.08;−0.67)) and lower social need fulfillment (−4.52(−4.67;−4.36)) are associated with lower mental health-related quality of life. Higher neighborhood deprivation was also associated with lower mental health related quality of life (−0.18(−0.24;−0.11)), but only for those with few personal contacts or low social need fulfillment. Our results suggest that social relations buffer the effect of neighborhood deprivation on mental health-related quality of life.

1. Introduction

Health-related quality of life is a concept used to assess how diseases affect individual well-being. Health-related quality of life refers to a person's level of physical, emotional, and social functioning and is measured using objective and subjective evaluations. Health-related quality of life is not only affected by individual factors, such as diseases, life style factors and social support, but also by factors related to the environment in which people live (Dale et al., 2013; Netuveli et al., 2006). For example, studies in Europe, the U.S., Australia and South America have consistently shown that individuals living in neighborhoods of higher socioeconomic deprivation have a lower health-related quality of life than individuals living in neighborhoods of lower socioeconomic deprivation (Gary-Webb et al., 2011; Wainwright and Surtees, 2004; Zhang et al., 2011; Myint et al., 2009; Adams et al., 2009; Pruitt et al., 2012; Feldman and Steptoe, 2004; Duran et al., 2013; Zenk et al., 2005; Sampson et al., 1997; Lovasi et al., 2009). This association is irrespective of a person's own socioeconomic position (Gary-Webb et al., 2011; Wainwright and Surtees, 2004; Zhang et al., 2011; Myint et al., 2009; Adams et al., 2009; Pruitt et al., 2012; Feldman and Steptoe, 2004). The association between neighborhood socioeconomic deprivation and health-related quality of life can partly be explained by a lower availability of healthy food stores and community resources, smaller social cohesion, and higher crime rates in neighborhoods of higher socioeconomic deprivation (Zhang et al., 2011; Zenk et al., 2005; Sampson et al., 1997; Lovasi et al., 2009). It is unknown whether and to what extent differences in the prevalence of diseases across neighborhoods play a role in the explanation of the association between neighborhood deprivation and health-related quality of life.

Next to the neighborhood in which a person lives, health-related quality of life is affected by a person's social relationships (Nyqvist et al., 2013; Thoits, 2011; de Belvis et al., 2008; Netuveli et al., 2006; Steverink and Lindenberg, 2006). Studies have shown that both objective aspects, such as the number of personal contacts, and subjective aspects of social relationships, such as the fulfillment of social needs, are important for health-related quality of life (Nyqvist et al., 2013; Thoits, 2011; de Belvis et al., 2008; Netuveli et al., 2006; Steverink and Lindenberg, 2006). Social need fulfillment theory states that everyone has intrinsic social needs, including affection, behavioral confirmation and status (Steverink and Lindenberg, 2006; Ormel et al., 1999; Nieboer et al., 2005). Quality of life has been shown to be dependent on the extent to which these intrinsic social needs are fulfilled (Steverink and Lindenberg, 2006; Nieboer et al., 2005).

Besides a direct effect, social relationships have an indirect effect on health-related quality of life. According to Cohen's stress buffering hypothesis, social relationships can buffer the effect of external stressors on health and related outcomes (Helgeson, 2003; Cohen

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and Wills, 1985). Thoits suggested seven mechanisms through which social relationships can buffer the effect of external stressors (Thoits, 2011). These mechanisms are social influence, social control, role-based purpose and meaning, self-esteem, sense of control, belonging and companionship, and perceived support availability (Thoits, 2011). Persons who live in a neighborhood of higher deprivation experience more stress (Brenner et al., 2013; Boardman et al., 2001). To our knowledge, it is unknown whether social relations can buffer the effect of neighborhood deprivation on health-related quality of life. Therefore, our aim is to investigate to what extent personal contacts and social need fulfillment buffer the effect of neighborhood deprivation on health-related quality of life.

2. Methods

2.1. Study population

We used data from the adults baseline subsample of the Dutch LifeLines cohort study (Scholtens et al., 2015; Klijs et al., 2015; Stolk et al., 2008). The cohort profile of LifeLines is described elsewhere (Scholtens et al., 2015). Briefly, LifeLines is a large population based representative cohort study and biobank in the three northern provinces of the Netherlands aiming to investigate universal risk factors for multifactorial diseases (Scholtens et al., 2015; Klijs et al., 2015; Stolk et al., 2008). The recruitment of participants (N=167,729) was carried out between 2006 and 2013. The LifeLines Cohort Study is conducted according to the principles of the Declaration of Helsinki and in accordance with research code University Medical Center Groningen (UMCG). The LifeLines Cohort Study is approved by the medical ethical committee of the UMCG, the Netherlands. All participants signed an informed consent form before they received an invitation for the physical examination. All participants visited one of the LifeLines research sites, where anthropometric and blood pressure measurements were taken and fasting blood samples were collected. Participants filled out extensive questionnaires including items on demographic and socioeconomic characteristics, chronic diseases, personal contacts and social need fulfillment. We used a first released dataset of adult participants whose home addresses had been geocoded and linked with information on the participants' neighborhoods (reference year 2011) available through Statistics Netherlands (N=68,761) (Statistics Netherlands, 2013). We excluded 650 individuals (0.9%) with missing measurements on health-related quality of life, which resulted in a final study sample of 68,111 individuals.

2.2. Health-related quality of life

Health-related quality of life was measured using the Dutch version of the RAND-36 (Hays and Morales, 2001; van der Zee and Sanderman, 1993). The RAND-36 is composed of eight multi-item scales (35 items) assessing physical functioning (10 items), role limitations due to physical health problems (4 items), bodily pain (2 items), general health (5 items), vitality (4 items), social functioning (2 items) role limitations due to emotional problems (3 items), and emotional well-being (5 items) (Hays and Morales, 2001; van der Zee and Sanderman, 1993). Using a standard procedure, the eight scales were aggregated into a mental (MCS) and physical component summary score (PCS) (Ware et al., 1994). The MCS and PCS are between 0 and 100. A higher score indicates a better health-related quality of life. The RAND-36 has good psychometric qualities and has been shown to be a responsive measure of population health (van der Zee et al., 1996; Hemingway et al., 1997).

2.3. Index of neighborhood deprivation

Information on the percentage of low income households, the percentage of persons (aged 15–65 years) receiving assistance benefits, and the percentage of owner occupied houses in the participants' neighborhoods was available through Statistics Netherlands (Statistics Netherlands, 2013). These percentages can be seen as proxy indicators of material resources, wealth and insecurity in the participants' neighborhoods (Myint et al., 2009). Following earlier studies that investigated the relationship between neighborhood conditions and functional health, the three indicators of socioeconomic conditions were aggregated into a single index of neighborhood socioeconomic status, using principal component analysis (Myint et al., 2009). The loadings of separate indicators on the index were 0.55 or higher. The index explained 85% of the overall variability. The index was Z-standardized.

2.4. Number of personal contacts and social need fulfillment

Individuals were asked to report the number of different persons with whom they had contact on average within two weeks' time (continuous scale). People were instructed only to count those contacts in which personal matters were exchanged or discussed, either through written or oral communication. The number of personal contacts was categorized as less than 5, 5–9, 10–14, and 15 or more contacts in two weeks. Social need fulfillment was assessed using the nine items on social well-being from the short version of the Social Production Function Instrument for the Level of well-being (SPF-IL) (Steverink and Lindenberg, 2006; Nieboer et al., 2005). These nine items of the SPF-IL assess affection (3 items), behavioral confirmation (3 items) and status (3 items) (Steverink and Lindenberg, 2006; Nieboer et al., 2005). Behavioral confirmation is the feeling of doing the 'right' thing in the eyes of 'relevant' others or yourself (Steverink and Lindenberg, 2006; Nieboer et al., 2005). Examples of the items assessed are 'Do you feel that people really love you?', 'Do you feel useful to others?' and 'Are you known for the things you have accomplished?'. All items in the SPF-IL have the following answer categories: never, sometimes, often, and always. Each item is scored on a 4-point scale (range 0–3) (Steverink and Lindenberg, 2006; Nieboer et al., 2005). The item scores were summed to calculate an overall social need fulfillment score. Social need fulfillment was categorized as 'low' (< =14 points), 'middle' (15–17 points) and 'high' (18–27 points). The SPF-IL is a valid and reliable measure of social need fulfillment (Nieboer et al., 2005). The categorization for 'number of personal contacts' and 'social need fulfillment' was chosen in such a way that the categories captured the non-linear relationships with health-related quality of life and resulted in a sufficient number of persons in each category. In our data, the correlation between number of personal contacts and social need fulfillment was only low (Cramer's V of 0.11).

2.5. Other control variables

The household equivalent income was calculated as the net household income divided by the square root of the number of persons living on this amount (Organization for Economic Cooperation and Development, 2011). Household equivalent income was categorized into less than €1000, €1000 to €1299, €1300 to €1599, €1600 to €1899, and €1900 or more per month and 'don't know or prefer not to answer'. Highest education obtained was categorized into elementary (no or primary education), lower secondary (junior secondary pre-vocational education, junior general secondary education), upper secondary (senior general secondary or pre-university education), and tertiary (higher professional education or university). Several diseases are associated with lower health-related quality of life (Garin et al., 2014; Dale et al., 2013). To control for chronic diseases in our analysis, variables indicating the presence of absence (1 or 0) of the following diseases were constructed: depression, panic disorder, other mental disorders, chronic non-specific lung disease, cancer, diabetes mellitus, myocardial infarction, stroke, osteoarthritis, rheumatoid arthritis, and incontinence. Other control variables were age (contin-

uous), sex (male/female), and married (yes/no). Ethnicity was no potential confounder in our analysis because 97% of our study population was born in the Netherlands. Employment is a potential confounder of the relationship between neighborhood deprivation and health-related quality of life. However, unemployment can reduce health-related quality of life by leading to fewer personal contacts or lower social need fulfillment. This means that controlling for unemployment can result in an underestimation of the buffering effect of social relations on health-related quality of life. Therefore, we did not include a variable for employment in our main analysis but evaluated whether controlling for "current involvement in paid work" changed our regression estimates and substantive conclusion. We did not include neighborhood factors other than neighborhood deprivation in the regression models because neighborhood factors are strongly correlated and including them together in one model led to multicollinearity.

2.6. Statistical analysis

Characteristics of the study participants and the study participants' neighborhoods are presented for all residential areas and according to neighborhood deprivation (score on index lower than −1, −1 to 1, 1 or higher). Univariate and multivariate mixed effect linear regression models were used to assess the associations of neighborhood deprivation, number of personal contacts, and social need fulfillment with health-related quality of life (MCS and PCS). A random intercept was included to account for clustering of observations within neighborhoods. In the multivariate analysis, the following groups of independent variables are included: model 1: neighborhood deprivation, number of personal contacts, social need fulfillment, age, sex, marital status, highest education, household equivalent income; model 2: model 1+ chronic diseases; model 3: model 2+ interaction neighborhood deprivation*number of personal contacts; model 4: model 2+ interaction neighborhood deprivation*social need fulfillment. For all models, the standard deviation of the random intercept for neighborhood was presented as a measure of variation across neighborhoods. Using model 3 and 4, we estimated MCSs by neighborhood deprivation (1st and 9th decile of index), personal contacts and social need fulfillment. Missing measurements of all independent variables were assumed to be at random (MAR) and were multiply imputed using a multivariate normal model using MCS, PCS, age, sex, depression, panic disorder, other mental disorders, osteoarthritis, rheumatoid arthritis, and incontinence as predictor variables. The percentages of missing measurements for each variable are shown in Table 1. In the northern part of the Netherlands, a large part of the individuals aged 18–30 are students, who generally have a low income but a prospect of a high socioeconomic position. We performed a sensitivity analysis in which we evaluated to what extent the associations changed when individuals aged 18–30 years were excluded. A complete case analysis was performed to evaluate the potential impact of the imputation procedure on our substantive conclusions. The index of neighborhood deprivation was calculated using data from the year 2011, which was the year in which half of the LifeLines study population had been recruited. Differences in the association between neighborhood deprivation and health-related quality of life by year of the participants' participation in the LifeLines Cohort Study were evaluated by including interaction terms of neighborhood deprivation*study year to model 2. It is standard to control for marital status. However, being married or having a (registered) partnership is related with a person's number of personal contacts and social need fulfillment. Controlling for marital status may lead to an underestimation of the buffering effect of social relations. Therefore, we evaluated whether and how our regression estimates changed when we did not control for marital status. Intraclass correlation coefficients (ICC) could only be calculated in the complete case analyses, because the Stata command to calculate ICCs (xtmrho) cannot be used together with the command for multiple imputation (mi impute mvn). All analysis where performed in StataMP 13 (64-bit).

Table 1
Characteristics of the study population.

	All residential areas	Neighborhood deprivation		
		Low (Score < −1)	Middle (Score −1 to 1)	High (Score > =1)
N	68,111	10,346	47,975	9790
Health-related quality of life				
Mental Component Score (mean, sd)	50.4 (8.8)	51.1 (8.2)	50.5 (8.7)	49.0 (9.6)
Physical Component Score (mean, sd)	52.5 (7.1)	53.1 (6.5)	52.4 (7.2)	52.4 (7.5)
Personal contacts[a]				
% less than 5	10.7	9.1	11.0	11.0
% 5–9	18.5	17.6	18.5	19.3
% 10–14	21.8	20.9	21.8	22.6
% 15 or more	46.7	50.6	46.3	44.6
% Missing	2.3	1.9	2.4	2.5
Social need fulfillment[b]				
% Low	28.8	25.7	29.3	29.4
% Medium	36.9	38.6	36.8	35.6
% High	30.7	33.0	30.0	31.5
% Missing	3.6	2.8	3.8	3.6
Age (mean, sd)	43.6 (11.6)	44.8 (10.2)	44.0 (11.6)	40.4(12.7)
% Female	58.1	56.2	58	60.6
% Married or registered partnership	61.1	72.5	63.3	38.3
% Married missing	0.1	0.1	0.1	0.0
Highest education				
% Elementary	2.2	1.3	2.2	3.0
% Lower secondary	26.2	20.4	27.9	23.9
% Upper secondary	39.7	37.7	40.6	37.8
% Tertiary	29.8	38.6	27.2	33.1
% Missing	2.1	2.0	2.1	2.2
Household equivalent income 100€/month (mean,sd)	15.1 (5.7)	16.3 (5.5)	15.0 (5.6)	14.4 (6.0)
% Missing	14.6	14.7	15.1	11.9
Diseases				
% Depression	10.5	8.8	10.3	13.4
% Panic disorder	3.0	2.6	2.9	3.9
% Other mental disorder	3.4	2.6	3.3	4.5
% Chronic non-specific lung disease	5.2	4.5	5.2	5.7
% Cancer	3.9	4.2	4.0	3.6
% Diabetes Mellitus	2.1	1.6	2.1	2.4
% Myocardial infarction	0.9	0.6	0.9	0.9
% Stroke	0.6	0.4	0.6	0.7
% Osteoarthritis	6.4	6.1	6.6	5.4
% Rheumatoid arthritis	1.9	1.8	2.0	1.7
% Incontinence	2.0	2.0	2.0	2.2

[a] Number of personal contacts within two weeks in which personal matters are exchanged.
[b] Score on Social Production Function Instrument for the Level of well-being; < =14 is low, 15–17 is middle and 18–27 is low.

3. Results

Our study population consisted of 68,111 individuals, with a mean age of 43.6 years (sd 11.6). Of the participants, 58.1% were female and 61.1% were married or had a registered partnership. The mean MCS in

our study population was 50.4 (sd 8.8) and varied from 49.0 (sd 9.6) in neighborhoods of high deprivation to 51.1 (sd 8.2) in neighborhoods of low deprivation. The mean PCS was 52.5 (sd 7.1) and varied from 52.4 (sd 7.5) in neighborhoods of high deprivation to 53.1 (sd 6.5) in neighborhoods of low deprivation. Around half (49.0%) of the participants had 15 or more personal contacts and 10.7% of the participants had less than five personal contacts. One third (30.7%) of the study population had high social need fulfillment and 28.8% had low social need fulfillment. In general, persons from neighborhoods of higher deprivation had fewer personal contacts and lower social need fulfillment. Furthermore, persons living in neighborhoods of higher deprivation were slightly younger, were less often married or had a registered partnership, had a lower education and a lower household equivalent income. The prevalence of most diseases was higher in neighborhoods of higher deprivation. Details of the characteristics of our study population are presented in Table 1.

Our study participants resided in 1649 different neighborhoods. The mean number of participants per neighborhood was 41.3 (range 1–999). As compared with neighborhoods of low deprivation, neighborhoods of high deprivation were more frequently located in a strongly urbanized area with more than 1500 addresses/km^2 (74.4% versus 27.8%), and had a higher percentage of non-western migrants (17.8% versus 3.0%), single occupied houses (53.6% versus 19.3%), and persons older than 65 year (16.7% versus 12.0%). Characteristics of the study participants' neighborhoods are shown in Table 2.

Table 3 presents the results of the univariate and multivariate regression analysis on MCS. In the univariate regression analysis, all variables except cancer, myocardial infarction, and rheumatoid arthritis were significantly ($p < 0.05$) associated with MCS. In the multivariate regression analysis adjusted for age sex, marital status, education, and household equivalent income (model 1), higher neighborhood deprivation (b with 95% CI: −0.30 (−0.37;−0.22)), few personal contacts (b with 95% CI: −1.14 (−1.36;−0.93)) and low social need fulfillment (b with 95% CI: −5.32 (−5.48;−5.15)) were associated with lower MCS. These associations were attenuated when the analysis was adjusted for chronic diseases (model 2). There was a significant interaction effect of neighborhood deprivation*personal contacts (model 3; b with 95% CI: −0.33 (−0.54;−0.13)) and neighborhood deprivation*social need fulfillment (model 4; b with 95% CI: −0.47 (−0.62;−0.32)) on MCS.

Neighborhood deprivation (b with 95% CI: −0.22 (−0.29;−0.15)) and low social need fulfillment (b with 95% CI: −0.34 (−0.49;−0.20)) were also associated with lower PCS (Table 4, model 1). Interactions of neighborhood deprivation*personal contacts and neighborhood deprivation*social need fulfillment had no significant ($p < 0.05$) effect on PCS (Table 4, models 3 and 4).

Fig. 1 presents estimates of MCS by neighborhood deprivation, personal contacts, and social need fulfillment. For persons with less than five personal contacts or low social need fulfillment there is a large difference (1.3 points) in MCS between persons living in neighborhoods of low and high deprivation. For persons with 15 or more personal contacts or high social need fulfillment the MCS difference is only small (< 0.2 points).

3.1. Sensitivity analysis

Several sensitivity analyses were undertaken. The results in the tables are based on an imputed dataset. A complete case analysis of the data (N=54,028) showed no substantial differences in the regression estimates and significances and did not affect our conclusions (Table 5 Supplement). Also excluding persons younger than 30 years from our dataset did not alter our results (Table 6 Supplement). Interactions of neighborhood deprivation*study year were not significant (p MCS between 0.35 and 0.94; p PCS between 0,20 and 0,85) when included to model 2, which indicates that the association between neighborhood deprivation and health-related quality of life did not differ by year of participation in the LifeLines Cohort Study. Leaving out "marital status" or including "current involvement in paid work" as control variables did not lead to different regression estimates and significances.

4. Discussion

Our aim was to investigate to what extent personal contacts and social need fulfillment buffer the effect of neighborhood deprivation on health-related quality of life. In our data, we found a differential effect of neighborhood deprivation on mental health-related quality of life by number of personal contacts and social need fulfillment. Among persons with relatively few personal contacts or low social need fulfillment, we found a strong effect of neighborhood deprivation on mental health-related quality of life. Among persons with many personal contacts or high social need fulfillment, we did not find an effect of neighborhood deprivation on mental health related quality of life. These results suggest that personal contacts and social need fulfillment buffer the effect of neighborhood deprivation on mental health-related quality of life. We did not find a differential effect of neighborhood deprivation on physical health-related quality of life by number of personal contacts or social need fulfillment.

To our knowledge, our study is the first to demonstrate that social relations buffer the effect of living in a deprived neighborhood on

Table 2
Characteristics of the study participants' neighborhoods.

	All residential areas	Neighborhood deprivation		
		Low (Score < −1)	Middle (Score −1 to 1)	High (Score > =1)
N	1649	333	1046	270
Demographic characteristics				
Neighborhoods in strongly urbanized area[a] (N,%)	459 (27.8)	35 (10.5)	223 (21.3)	201 (74.4)
Residents per neighborhood (mean, sd)	2,370(2,496)	1,417(1,342)	2,320(2,208)	3,740(3,740)
Non-western migrants (%, sd)	6.2(9.1)	3.0(5.1)	4.3(5.4)	17.8(14.4)
Single occupied households (%, sd)	33.3(15.3)	19.3(7.8)	32.5(11.6)	53.6(13.4)
Persons older than 65 years (%, sd)	15.6(8.1)	12.0(6.7)	16.5(7.7)	16.7(9.7)
Socioeconomic characteristics				
Low-income households[b] (%, sd)	40.1(14.0)	23.0(6.5)	39.9(8.0)	61.8(8.0)
Households receiving assistance benefits (%, sd)	4.1(3.8)	1.2(0.7)	3.5(2.0)	10.2(4.7)
Owner occupied houses (%, sd)	61.6(20.2)	84.0(6.5)	63.2(11.7)	27.9(11.8)

[a] More than 1500 addresses per km^2;
[b] Disposable household income less than €25,100 per year.

Table 3
Univariate and multivariate mixed effect linear regression models on Mental Component Score (MCS) of health-related quality of life.

	Univariate linear regression models	Multivariate linear regression models			
		Model 1	Model 2	Model 3	Model 4
Neighborhood deprivation	−0.69 (−0.77;−0.61)	−0.30 (−0.37;−0.22)	−0.18 (−0.24;−0.11)	−0.06 (−0.15;0.03)	−0.06 (−0.17;0.05)
Personal contacts[a]					
15 or more	Ref.	Ref.	Ref.	Ref.	Ref.
10–14	−0.93 (−1.11;−0.76)	−0.45 (−0.62;−0.29)	−0.36 (−0.51;−0.20)	−0.36 (−0.52;−0.21)	−0.36 (−0.51;−0.21)
5–9	−1.81 (−1.99;−1.63)	−0.91 (−1.08;−0.74)	−0.74 (−0.91;−0.58)	−0.75 (−0.91;−0.58)	−0.75 (−0.91;−0.58)
Less than 5	−2.17 (−2.40;−1.95)	−1.14 (−1.36;−0.93)	−0.88 (−1.08;−0.67)	−0.87 (−1.07;−0.67)	−0.87 (−1.07;−0.67)
Neighborhood deprivation*personal contacts					
15 or more	Ref.			Ref.	
10–14	−0.27 (−0.44;−0.10)			−0.20 (−0.35;−0.05)	
5–9	−0.24 (−0.42;−0.06)			−0.17 (−0.33;−0.01)	
Less than 5	−0.57 (−0.79;−0.34)			−0.33 (−0.54;−0.13)	
Social need fulfillment[b]					
High	Ref.	Ref.	Ref.	Ref.	Ref.
Medium	3.96 (3.79;4.12)	−1.57 (−1.72;−1.41)	−1.40 (−1.55;−1.26)	−1.40 (−1.55;−1.26)	−1.40 (−1.55;−1.25)
Low	5.69 (5.52;5.85)	−5.32 (−5.48;−5.15)	−4.52 (−4.67;−4.36)	−4.52 (−4.67;−4.36)	−4.51 (−4.66;−4.35)
Neighborhood deprivation*social need fulfillment					
High	Ref.				Ref.
Medium	0.05 (−0.11;0.21)				0.04 (−0.11;0.19)
Low	−0.63 (−0.79;−0.47)				−0.47 (−0.62;−0.32)
Age	0.07 (0.07;0.08)	0.05 (0.04;0.05)	0.06 (0.05;0.06)	0.06 (0.05;0.06)	0.06 (0.05;0.06)
Female	−2.07 (−2.20;−1.93)	−1.60 (−1.73;−1.47)	−1.11 (−1.23;−0.98)	−1.11 (−1.23;−0.98)	−1.11 (−1.24;−0.99)
Married or registered partnership	2.40 (2.26;2.53)	1.69 (1.55;1.83)	1.35 (1.21;1.48)	1.35 (1.21;1.48)	1.35 (1.21;1.48)
Highest education					
Tertiary	Ref.	Ref.	Ref.	Ref.	Ref.
Upper secondary	−0.30 (−0.46;−0.14)	0.65 (0.49;0.80)	0.71 (0.56;0.86)	0.71 (0.56;0.86)	0.70 (0.56;0.85)
Lower secondary	−0.29 (−0.48;−0.11)	0.62 (0.44;0.81)	0.69 (0.51;0.86)	0.69 (0.51;0.86)	0.68 (0.51;0.86)
Elementary	−1.59 (−2.05;−1.12)	−0.23 (−0.69;0.22)	0.13 (−0.30;0.56)	0.14 (−0.29;0.57)	0.15 (−0.28;0.58)
Household equivalent income					
100 €/month; (mean, sd)	0.19 (0.17;0.20)	0.11 (0.10;0.13)	0.08 (0.07;0.10)	0.08 (0.07;0.10)	0.08 (0.07;0.10)
Diseases					
Depression	−9.43 (−9.63;−9.23)		−7.31 (−7.51;−7.10)	−7.30 (−7.51;−7.10)	−7.29 (−7.49;−7.08)
Panic disorder	−8.31 (−8.69;−7.93)		−3.15 (−3.51;−2.78)	−3.15 (−3.51;−2.78)	−3.15 (−3.51;−2.78)
Other mental disorders	−8.69 (−9.04;−8.33)		−4.33 (−4.67;−3.98)	−4.32 (−4.66;−3.97)	−4.31 (−4.65;−3.96)
Chronic non-specific lung disease	−1.28 (−1.57;−0.98)		−0.71 (−0.98;−0.44)	−0.71 (−0.98;−0.44)	−0.71 (−0.97;−0.44)
Cancer	0.20 (−0.14;0.54)		−0.10 (−0.41;0.21)	−0.11 (−0.41;0.20)	−0.11 (−0.42;0.19)
Diabetes Mellitus	−0.58 (−1.05;−0.12)		−0.32 (−0.74;0.10)	−0.32 (−0.74;0.10)	−0.32 (−0.74;0.10)
Myocardial infarction	−0.09 (−0.81;0.62)		−1.26 (−1.91;−0.61)	−1.26 (−1.91;−0.61)	−1.25 (−1.90;−0.60)
Stroke	−1.28 (−2.14;−0.43)		−0.93 (−1.70;−0.16)	−0.92 (−1.69;−0.15)	−0.93 (−1.70;−0.16)
Osteoarthritis	0.56 (0.29;0.83)		0.52 (0.27;0.77)	0.52 (0.27;0.77)	0.52 (0.26;0.77)
Rheumatoid arthritis	0.02 (−0.46;0.51)		−0.03 (−0.47;0.41)	−0.03 (−0.47;0.40)	−0.03 (−0.47;0.40)
Incontinence	−3.09 (−3.55;−2.62)		−1.31 (−1.73;−0.88)	−1.30 (−1.72;−0.88)	−1.30 (−1.73;−0.88)
sd random intercept neighborhood		0.46 (0.36;0.58)	0.31 (0.21;0.45)	0.31 (0.21;0.45)	0.31 (0.21;0.45)

[a] Number of personal contacts within two weeks in which personal matters are exchanged.
[b] Score on Social Production Function Instrument for the Level of well-being; < =14 is low, 15–17 is middle and 18–27 is low.

mental health-related quality of life. Our study suggests that both the objective aspects, such as the number of contacts, and subjective aspect of social relations, such as social need fulfillment, are important. An obvious question is which specific mechanisms can explain why social relationships buffer the effect of neighborhood deprivation on mental health-related quality of life. According to Feldman et al. and Pruitt et al., the effect of neighborhood deprivation on health-related quality of life is explained by financial strain, overweight, lack of physical activity, low perceived control, and poor social integration (Pruitt et al., 2012; Feldman and Steptoe, 2004). Thoits suggested that social relations can buffer the effect of external exposures on health and related outcomes through seven mechanisms, namely social influence, social control, role-based purpose and meaning, self-esteem, sense of control, belonging and companionship, and perceived support availability (Thoits, 2011). Together, these studies give a first hint of the mechanisms through which social relation can buffer the effect of neighborhood deprivation on mental health-related quality of life. For example, material support (perceived support availability) from social relations can reduce the risk of financial strain. Financial strain is one of the factors explaining the relation between neighborhood deprivation and health-related quality of life. Therefore, one of the mechanisms through which social relations can buffer the effect of neighborhood deprivation on health related quality of life is by providing material support. Furthermore, social relations can provide a sense of belonging, and thereby improve social integration. As poor social integration explains part of the association between neighborhood deprivation and health-related quality of life, social relations can buffer the effect of neighborhood deprivation through sense of belonging. Another example is that social relations can buffer the effect of neighborhood deprivation on health related quality of life by a positive effect on physical activity through social influence. In our analysis, leaving out marital status as a control variable did not lead to different

Table 4
Univariate and multivariate mixed effect linear regression models on Physical Component Score (PCS) of health-related quality of life.

	Univariate linear regression models	Multivariate linear regression models			
		Model 1	Model 2	Model 3	Model 4
Neighborhood deprivation	−0.16 (−0.24;−0.08)	−0.22 (−0.29;−0.15)	−0.15 (−0.22;−0.09)	−0.15 (−0.24;−0.07)	−0.18 (−0.28;−0.09)
Personal contacts[a]					
15 or more	Ref.	Ref.	Ref.	Ref.	Ref.
10–14	−0.08 (−0.22;0.06)	0.10 (−0.04;0.23)	0.05 (−0.08;0.18)	0.05 (−0.08;0.18)	0.05 (−0.08;0.18)
5–9	−0.14 (−0.28;0.01)	0.17 (0.03;0.31)	0.16 (0.02;0.30)	0.16 (0.02;0.30)	0.16 (0.02;0.30)
less than 5	−0.71 (−0.89;−0.53)	−0.06 (−0.24;0.12)	−0.07 (−0.24;0.10)	−0.06 (−0.24;0.11)	−0.07 (−0.24;0.10)
Neighborhood deprivation*personal contacts					
15 or more	Ref.			Ref.	
10–14	0.06 (−0.08;0.19)			0.06 (−0.07;0.18)	
5–9	−0.03 (−0.18;0.12)			0.00 (−0.14;0.14)	
less than 5	−0.34 (−0.52;−0.15)			−0.12 (−0.29;0.05)	
Social need fulfillment[b]					
High	Ref.	Ref.	Ref.	Ref.	Ref.
Medium	−0.02 (−0.15;0.12)	0.05 (−0.08;0.18)	0.02 (−0.11;0.14)	0.02 (−0.11;0.14)	0.02 (−0.10;0.14)
Low	−0.81 (−0.96;−0.67)	−0.34 (−0.49;−0.20)	−0.20 (−0.34;−0.06)	−0.20 (−0.34;−0.06)	−0.20 (−0.34;−0.06)
Neighborhood deprivation*social need fulfillment					
High	Ref.				Ref.
Medium	0.09 (−0.04;0.22)				0.07 (−0.05;0.19)
Low	−0.02 (−0.16;0.12)				0.01 (−0.12;0.15)
Age	−0.09 (−0.10;−0.09)	−0.09 (−0.09;−0.08)	−0.03 (−0.04;−0.03)	−0.03 (−0.04;−0.03)	−0.03 (−0.04;−0.03)
Female	−0.92 (−1.03;−0.81)	−0.87 (−0.98;−0.77)	−0.59 (−0.69;−0.49)	−0.59 (−0.69;−0.49)	−0.59 (−0.69;−0.49)
Married or registered partnership	−0.53 (−0.65;−0.42)	0.17 (0.05;0.29)	−0.04 (−0.16;0.07)	−0.04 (−0.16;0.07)	−0.04 (−0.16;0.07)
Highest education					
Tertiary	Ref.	Ref.	Ref.	Ref.	Ref.
Upper secondary	−0.99 (−1.11;−0.86)	−0.76 (−0.89;−0.63)	−0.68 (−0.81;−0.55)	−0.68 (−0.81;−0.56)	−0.68 (−0.81;−0.55)
Lower secondary	−2.45 (−2.59;−2.31)	−1.59 (−1.74;−1.43)	−1.37 (−1.52;−1.23)	−1.37 (−1.52;−1.22)	−1.37 (−1.52;−1.22)
Elementary	−4.50 (−4.87;−4.13)	−3.12 (−3.50;−2.75)	−2.46 (−2.82;−2.10)	−2.45 (−2.81;−2.09)	−2.46 (−2.82;−2.10)
Household equivalent income					
100 €/month (mean, sd)	0.09 (0.08;0.10)	0.07 (0.06;0.08)	0.05 (0.04;0.06)	0.05 (0.04;0.06)	0.05 (0.04;0.06)
Diseases					
Depression	−1.83 (−2.00;−1.65)		−1.01 (−1.18;−0.84)	−1.01 (−1.18;−0.84)	−1.01 (−1.18;−0.84)
Panic disorder	−1.41 (−1.72;−1.10)		−0.33 (−0.64;−0.02)	−0.33 (−0.64;−0.02)	−0.33 (−0.64;−0.02)
Other mental disorder	−1.32 (−1.62;−1.03)		−0.37 (−0.66;−0.08)	−0.37 (−0.66;−0.07)	−0.37 (−0.66;−0.07)
Chronic non-specific lung disease	−3.82 (−4.06;−3.58)		−2.79 (−3.02;−2.56)	−2.79 (−3.02;−2.56)	−2.79 (−3.02;−2.56)
Cancer	−2.22 (−2.49;−1.94)		−1.11 (−1.37;−0.85)	−1.11 (−1.37;−0.85)	−1.11 (−1.37;−0.85)
Diabetes Mellitus	−4.26 (−4.64;−3.89)		−2.45 (−2.81;−2.10)	−2.45 (−2.81;−2.10)	−2.45 (−2.81;−2.10)
Myocardial infarction	−4.60 (−5.18;−4.02)		−2.99 (−3.54;−2.44)	−2.99 (−3.54;−2.44)	−2.99 (−3.54;−2.44)
Stroke	−5.86 (−6.56;−5.17)		−4.13 (−4.79;−3.48)	−4.13 (−4.78;−3.47)	−4.13 (−4.79;−3.48)
Osteoarthritis	−6.82 (−7.03;−6.60)		−5.38 (−5.59;−5.16)	−5.38 (−5.59;−5.16)	−5.38 (−5.59;−5.16)
Rheumatoid arthritis	−7.82 (−8.21;−7.43)		−6.15 (−6.52;−5.78)	−6.15 (−6.52;−5.78)	−6.15 (−6.52;−5.78)
Incontinence	−4.88 (−5.26;−4.51)		−3.06 (−3.42;−2.70)	−3.06 (−3.42;−2.70)	−3.06 (−3.42;−2.70)
sd random intercept neighborhood		0.49 (0.41;0.58)	0.42 (0.34;0.51)	0.42 (0.34;0.51)	0.42 (0.35;0.51)

[a] Number of personal contacts within two weeks in which personal matters are exchanged.
[b] Score on Social Production Function Instrument for the Level of well-being; < =14 is low, 15–17 is middle and 18–27 is low.

regression estimates and significances. This suggests that the buffering effect of social relations is not explained by (aspects of) formalized intimate relationships.

We found that personal contacts and social need fulfillment buffer the effect of neighborhood deprivation on mental but not on physical health-related quality of life. This difference may be explained by the fact that the questions that were used to assess the number of personal contacts and social need fulfillment put a greater emphasis on mental than on physical or material support. Another explanation is that the causal pathways from social relation to mental health are shorter than the pathways to physical health (Berkman et al., 2000). It could be that the shorter pathways from social relations to mental health are more easily detected in a cross-sectional study like ours.

One earlier study by Stockdale et al. has shown that social support buffers the effect of neighborhood deprivation on alcohol, drug, and mental disorders (Stockdale et al., 2007). Our results show that social relations buffer the effect of neighborhood deprivation on a broader set of health outcomes, including mental health-related quality of life. A number of previous studies have found that neighborhood deprivation is associated with a lower health-related quality of life (Gary-Webb et al., 2011; Wainwright and Surtees, 2004; Zhang et al., 2011; Myint et al., 2009; Adams et al., 2009; Pruitt et al., 2012; Feldman and Steptoe, 2004). None of these studies, however, investigated to what extent the association between neighborhood deprivation and health-related quality of life is explained by chronic diseases. Our study is the first to show that neighborhood deprivation has an effect on health-related quality of life, irrespective of mental and physical diseases.

4.1. Methodological considerations

The mean MCS in our study (50.4) was comparable to other Dutch studies (MCS between 48.1 and 51.1) (National Institute for Public

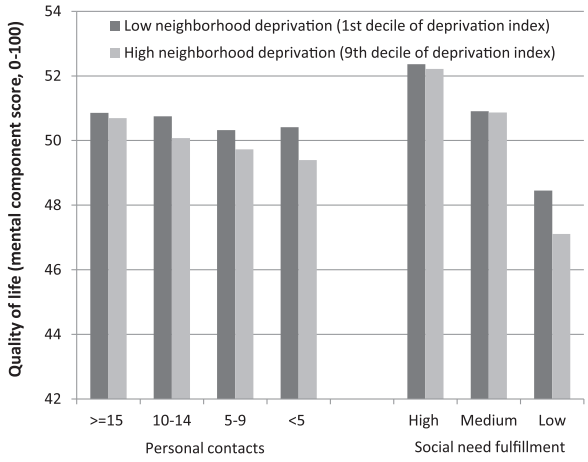

Fig. 1. Mental Component Score (MCS) of health-related quality of life by neighborhood deprivation, number of personal contacts and social need fulfillment.

Health and the Environment, 2014). The mean PCS in our study (52.5) was slightly higher than in other studies. This difference can be explained by different inclusion criteria of the studies (PCS between 48.1 and 51.1) (National Institute for Public Health and the Environment, 2014). One of the inclusion criteria in LifeLines was that persons had to be able to visit one of the LifeLines research centers. A main strength of our study is the large study population of 68,111 persons living 1649 neighborhoods. Another strength is that we used a composite indicator of neighborhood deprivation to cover multiple aspects of socioeconomic deprivation. Furthermore, we used two indicators of social relations, i.e. personal contacts and social need fulfillment, which allowed us to investigate both objective and subjective aspects personal contacts in their function as a buffer. A limitation of our study is the cross-sectional study design, which does not allow drawing definitive conclusions on the direction of the associations that were found. The association between neighborhood deprivation and health-related quality of life may represent a true effect of neighborhood deprivation, but may also partly reflect an effect of health related migration. When persons with a low health-related quality of life are, for some reason, more inclined to move to or stay in neighborhoods of higher deprivation, this would also lead to an association between neighborhood deprivation and health-related quality of life. Furthermore, the associations of personal contacts and social need fulfillment with health-related quality of life may partly be due to an underlying common cause. Chronic diseases are associated with health-related quality of life and neighborhood deprivation, and are an example of an underlying common cause that can explain the association of personal contacts and social need fulfillment with health related quality of life. We controlled our analysis for various mental and somatic diseases to adjust for effects of health related migration and confounders of the associations of personal contacts, social need fulfillment and health-related quality of life. The cross-sectional study design also puts a restriction on the interpretation of the interactive effect of neighborhood deprivation and social relations to mental health-related quality of life, we found in our study. The interactive effect supports the hypothesis that social relations protect against the effect of neighborhood deprivation, however, it could also be that living in a neighborhood of a high socioeconomic status protects against the detrimental effect of having poor or few social relations.

4.2. Implications

One of the great challenges of population ageing is the preservation of quality of life in the elderly population (World Health Organization,

Table 5
Supplement Mixed effect linear regression models on Mental (MCS) and Physical Component Score (PCS) of health-related quality of life for persons with complete information on all variables.

	Multivariate linear regression models					
	Mental component score			Physical component score		
	Model 2	Model 3	Model 4	Model 2	Model 3	Model 4
Neighborhood deprivation	−0.17 (−0.24;−0.10)	−0.05 (−0.15;0.05)	−0.05 (−0.16;0.07)	−0.15 (−0.21;−0.08)	−0.15 (−0.24;−0.06)	−0.16 (−0.26;−0.06)
Personal contacts[a]						
15 or more	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
10–14	−0.34 (−0.51;−0.17)	−0.34 (−0.51;−0.17)	−0.34 (−0.51;−0.17)	0.13 (−0.01;0.27)	0.12 (−0.02;0.27)	0.13 (−0.01;0.27)
5–9	−0.79 (−0.97;−0.61)	−0.79 (−0.98;−0.61)	−0.79 (−0.98;−0.61)	0.20 (0.05;0.35)	0.20 (0.05;0.35)	0.20 (0.05;0.35)
less than 5	−0.95 (−1.18;−0.72)	−0.94 (−1.17;−0.71)	−0.94 (−1.17;−0.71)	0.03 (−0.16;0.22)	0.04 (−0.15;0.23)	0.03 (−0.16;0.22)
Neighborhood deprivation*personal contacts						
15 or more						
10–14		−0.22 (−0.39;−0.06)			0.07 (−0.07;0.21)	
5–9		−0.17 (−0.35;0.00)			0.00 (−0.15;0.15)	
less than 5		−0.36 (−0.59;−0.13)			−0.17 (−0.36;0.02)	
Social need fulfillment[b]						
High	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Medium	−1.43 (−1.58;−1.27)	−1.43 (−1.58;−1.27)	−1.42 (−1.58;−1.26)	0.02 (−0.12;0.15)	0.01 (−0.12;0.15)	0.02 (−0.12;0.15)
Low	−4.54 (−4.72;−4.37)	−4.54 (−4.71;−4.36)	−4.52 (−4.70;−4.35)	−0.20 (−0.35;−0.06)	−0.20 (−0.35;−0.06)	−0.20 (−0.35;−0.06)
Neighborhood deprivation*social need fulfillment						
High			Ref.			Ref.
Medium			0.07 (−0.08;0.23)			0.03 (−0.10;0.16)
Low			−0.52 (−0.69;−0.35)			0.00 (−0.14;0.14)
sd random intercept neighborhood	0.07 (0.02;0.22)	0.06 (0.02;0.22)	0.06 (0.02;0.22)	0.19 (0.12;0.29)	0.19 (0.12;0.29)	0.19 (0.12;0.29)
Intraclass Correlation Coefficient	0.001 (0.000;0.004)	0.001 (0.000;0.004)	0.001 (0.000;0.004)	0.004 (0.003;0.007)	0.004 (0.003;0.007)	0.004 (0.003;0.007)

[a] Number of personal contacts within two weeks in which personal matters are exchanged.
[b] Score on Social Production Function Instrument for the Level of well-being; < =14 is low, 15–17 is middle and 18–27 is low. All models are adjusted for age, sex, marital status, education, household equivalent income and diseases.

Table 6
Supplement Mixed effect linear regression models on Mental (MCS) and Physical Component Score (PCS) of health-related quality of life for persons older than 30 years.

	Multivariate linear regresion models					
	Mental component score			Physical component score		
	Model 2	Model 3	Model 4	Model 2	Model 3	Model 4
Neighborhood deprivation	−0.15 (−0.23;−0.08)	−0.03 (−0.14;0.07)	−0.01 (−0.13;0.12)	−0.20 (−0.27;−0.13)	−0.19 (−0.28;−0.09)	−0.23 (−0.34;−0.12)
Personal contacts[a]						
15 or more						
10–14	−0.37 (−0.53;−0.20)	−0.38 (−0.55;−0.21)	−0.37 (−0.53;−0.20)	0.05 (−0.09;0.20)	0.05 (−0.09;0.20)	0.05 (−0.09;0.20)
5–9	−0.70 (−0.88;−0.52)	−0.72 (−0.90;−0.54)	−0.70 (−0.88;−0.53)	0.16 (0.00;0.31)	0.15 (0.00;0.31)	0.16 (0.00;0.31)
less than 5	−0.85 (−1.06;−0.63)	−0.85 (−1.06;−0.64)	−0.84 (−1.05;−0.62)	−0.07 (−0.25;0.12)	−0.07 (−0.25;0.12)	−0.07 (−0.25;0.12)
Neighborhood deprivation*personal contacts						
15 or more						
10–14		−0.17 (−0.35;0.00)			0.00 (−0.15;0.15)	
5–9		−0.20 (−0.38;−0.02)			0.01 (−0.15;0.17)	
less than 5		−0.34 (−0.55;−0.12)			−0.11 (−0.30;0.07)	
Social need fulfillment[b]						
High						
Medium	−1.39 (−1.55;−1.22)	−1.39 (−1.55;−1.22)	−1.38 (−1.55;−1.22)	0.00 (−0.14;0.14)	0.00 (−0.14;0.14)	0.01 (−0.13;0.15)
Low	−4.41 (−4.58;−4.25)	−4.41 (−4.58;−4.25)	−4.43 (−4.60;−4.26)	−0.18 (−0.33;−0.03)	−0.18 (−0.33;−0.03)	−0.18 (−0.32;−0.03)
Neighborhood deprivation*social need fulfillment						
High						
Medium			0.01 (−0.16;0.18)			0.08 (−0.07;0.22)
Low			−0.48 (−0.65;−0.30)			0.02 (−0.13;0.17)
sd random intercept neighborhood	0.30 (0.19;0.47)	0.30 (0.19;0.47)	0.29 (0.18;0.47)	0.38 (0.30;0.49)	0.38 (0.30;0.48)	0.38 (0.30;0.49)

[a] Number of personal contacts within two weeks in which personal matters are exchanged.
[b] Score on Social Production Function Instrument for the Level of well-being; < =14 is low, 15–17 is middle and 18–27 is low. All models are adjusted for age, sex, marital status, education, household equivalent income and diseases.

2015; Zaninotto et al., 2009). According to the World Health Organization, age-friendly environments are part of a solution to prevent declines in health-related quality of life (World Health Organization, 2007). Programs targeting the entire infrastructure of a neighborhood, however, are costly, and the evidence for the effectiveness of such interventions is inconsistent (Mehdipanah et al., 2013; Thomson, 2008; Jalaludin et al., 2012). Our study suggests that improving social relations can be an alternative to preserve (mental) health-related quality of life of persons living in deprived neighborhoods. Systematic reviews show that there are interventions that effectively reduce social isolation and improve well-being (Heaven et al., 2013; Dickens et al., 2011). Targeting these interventions to the groups that are most at risk for a low health-related quality of life, i.e. persons with a chronic disease living in neighborhoods of high deprivation, will help to prevent declines in health-related quality of life in the population.

Competing Interests

The authors declare that they have no competing interests.

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